SPECTROPHOTOMETRIC MAPPING OF DUST AND GAS IN SUPERNOVA REMNANTS

R. J. Tuffs(1), J. Fischera(1), I. Heinrichsen(1,2,3), C. Gabriel(2), L. O'C Drury(4), D. Innes(6) I. Rassmussen(5), H. Schnopper(5), H.J. Voelk(1)

1. Max-Planck Institut fuer Kernphysik, Heidelberg, Germany.
2. ISO SOC, Astrophysics Division of ESA, VILSPA, Madrid, Spain.
3. IPAC, California Institute of Technology, Pasadena, USA.
4. Dublin Institute for Advanced Studies, Dublin, Ireland.
5. Danish Space Science Research Institute, Copenhagen, Denmark.
6. Max-Planck Institut fuer Aeronomie, Katlenburg-Lindau, Germany.

The spectroscopic and imaging capabilities of **ISO** make it the first facility capable of distinguishing between, and thereby measuring, the separate emissions from solid-state, gaseous, and synchrotron-emitting species within SNRs. ISO is thereby providing new observational insight into fundamental issues such as the yield and composition of condensates in SN ejecta, the evolution and destruction of grains overtaken by shocks, and the measurement of cold ejected or swept-up gas inaccessible to optical/UV/X-ray observations. Here we present new results, obtained in the extended mission using **ISOPHOT** and **ISOCAM**, of the Crab Nebula, Cassiopeia A, and the remnant of SN1987A, representing young remnants of core collapse supernovae with contrasting progenitors.

Mapping spectrophotometry of the Crab Nebula with ISOPHOT-S in the 2.5 - 12 micron range reveals strong [Ar II], [Ar III] and [S IV] emission from the system of filaments, superimposed on a smooth continuum of nebular synchrotron emission. In contrast to Cas A, we did not detect dust continuum emission associated with the line emission, even in a pointed integration with ISOPHOT-S towards the most prominent patch of optical obscuration. The upper limits for mid-IR dust emission are interpreted in terms of the abundance, size distribution, and location within the filaments of the supernova condensates. Comparison of the ISOPHOT-C far-IR maps of the nebula in the 60 - 170 micron range with maps of the radio synchrotron emission indicate that the far-IR excess detected by IRAS is predominantly associated with the filaments. This could be due either to ejected condensates and/or line emission, and we use this data to place upper limits on the total mass of condensates in the ejecta. Evidence is presented for emission from molecules in the Crab's filaments, the most prominent of which we tentatively identify with CO. The resulting constraints on the isotopic ratio 16O/18O are discussed in relation to isotopic abundances predicted for the C-rich zones of core-collapse supernovae of various masses, and in relation to isotopic measurements of pre-solar grains.

We also present comprehensive mapping of Cas A with ISOPHOT-S, which extend the previously obtained ISOPHOT-S coverage of the northern shell to the whole area of the remnant. The dominant [Ar II], [Ar III] and [S IV] lines are seen in an almost complete, but extremely clumpy shell structure, with line ratios varying between the clumps. The dynamics and geometry of the shell is investigated using the radial velocities measured by ISOPHOT and compared to results from optically emitting ejecta. Dust emission mapped by PHT-S is compared with ISOCAM mapping of the whole remnant in a CVF channel sampling the continuum near 16.0 micron to investigate the variation of grain size distribution with position in the remnant, thereby providing information on the propagation of grains injected into the shell.

A point source close to the position of SN1987A in the LMC was detected by ISOCAM using the 3 arcsec pixel size in broadband filters centred at 11.5 and 15 microns. The precise position of this source was determined relative to a bright star in the ISOCAM field and compared to potential locations for the emission seen on HST images of the debris and surrounding ring structures. Assuming the emission is from dust, (consistent with upper limits on line emission obtained from ISOPHOT-S) the results are interpreted in the context of collisional and radiational stochastic grain heating constrained by X-ray and optical/UV studies of this object. Photometry in the 60 - 200 micron range with ISOPHOT-C is used to place upper limits on the total yield of condensates.